Broad band spectral properties of Seyfert 1 galaxies observed with BeppoSAX

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ABSTRACT

We will present some results on the broad–band observations of BeppoSAX of the bright Seyfert galaxies NGC 4151 and NGC 5548.

1 INTRODUCTION

In the last ten years the increased sensitivity, resolution and bandpass of X-ray missions have drastically changed our view of the X-ray spectrum of emission line AGN. We have moved from an almost featureless power law into a complex shape, where several broad and narrow features, produced in different sites around the central engine, are imprinted onto the power law. These components span a wide range of energies, sometimes overlapping with each other. An unambiguous determination of each component is then difficult, unless *simultaneous* broad–band spectral measurements are secured. BeppoSAX, with its 0.1-200 keV range, appears particularly suited to undertake a broad-band study of AGN in X-rays. In this contribution we will present some results of Core Program (and Science Verification Phase) observations devoted to the study of Broad-band spectral variability of Seyfert 1 galaxies. The scientific goals of the program are:

- Probe the environment near the central source. This is achieved by disentangling each spectral component and studying its temporal behaviour, in particular the response to changes of the intrinsic continuum and the correlation with other components.

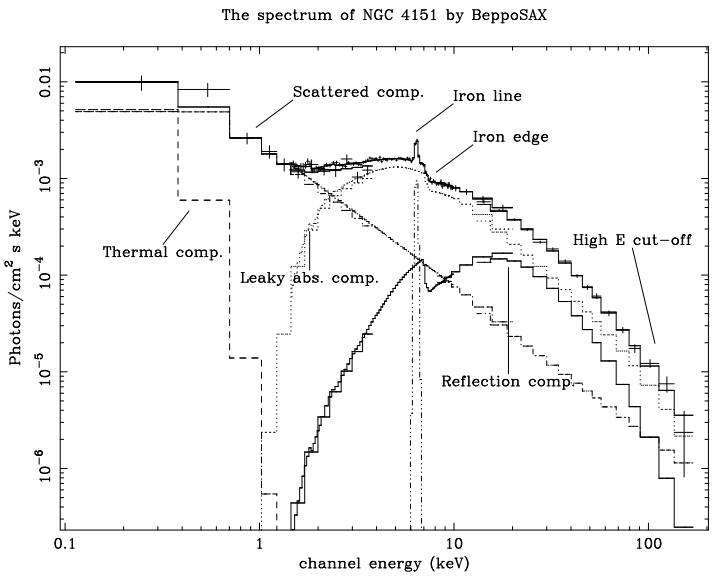

Figure 1: The BeppoSAX spectrum of NGC 4151

- Investigate the origin of the intrinsic continuum. The key spectral parameters of the continuum, i.e. the slope α and the high energy cut-off E_c can be determined with an unprecedented precision by BeppoSAX. This should allow to investigate the presence of correlation between those parameters and the luminosity, an important test-point for radiative models.

The baseline observing strategy we chose is that of long looks of those bright Seyfert 1 galaxies characterized by variability time-scale of $\sim$ day. This assures a contiguous sequence of spectra with the S/N needed for spectral measurements up to $\sim 100keV$ and without substantial variation within each time bin ($\leq$ variability time–scale).

We will present here some of the results obtained during the Science Verification Phase of NGC 4151, and during the AO1 on NGC 5548.

2 Broad–band spectral variability: a probe of the environment and of the origin of the intrinsic continuum

The X-ray spectrum of NGC4151 is the most complex ever observed in a Seyfert galaxy, as the broad-band picture of BeppoSAX clearly shows in Fig.1. The spectrum is characterized by features typical of both Seyfert 1 and Seyfert 2 galaxies, making NGC 4151 the best laboratory for the study of these objects. The different temporal behaviour of these components yields the complex spectral variability showed by this object. In fig.2 we present the ratio of spectra taken 2 days apart ($July_{HI}, July_{Low}$) and few months apart (Dec) in 1996. Let us first comment the long term behaviour (lower panel of Fig.2). All the variations can be attributed to a change in the structure of the absorber. The intrinsic continuum (cfr the ratio above 3-4 keV) remained unchanged, while below 1 keV the predominant constant soft components (Perola *et al.* 1986, Weaver *et al.* 1994) force to 1 the spectral ratio. The variability observed in July on $\sim$ day time–scale has a different origin. The factor–of–two flux increase is associated with a steepening of the intrinsic power law ($\Delta\alpha \sim 0.3$), fully consistent with the α vs. F_X relationship observed first with EXOSAT by Perola *et al.* 1986 and then confirmed with GINGA by Yaqoob *et al.* 1993. Fig.2 (upper panel) shows that the 2-10 keV spectral variability is indeed well reproduced by a change of the intrinsic slope. The presence of constant soft components dumps down to 1 the spectral ratio below 2

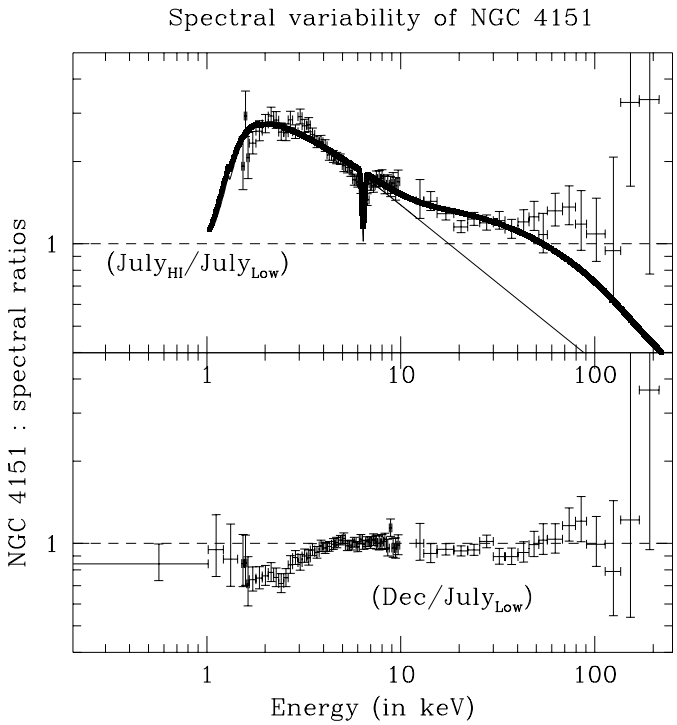

Figure 2: Spectral variability from BeppoSAX observations of NGC 4151. Upper panel: ratio of spectra of July 96 High and Low (taken 2 days apart). Lower panel: Dec. 96 over July 96 Low.

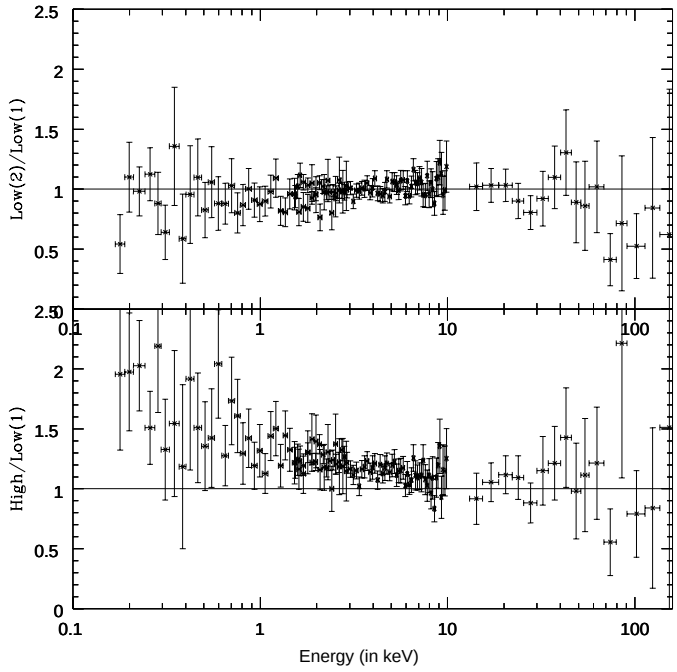

Figure 3: Spectral variability of of NGC 5548 from the BeppoSAX long–look

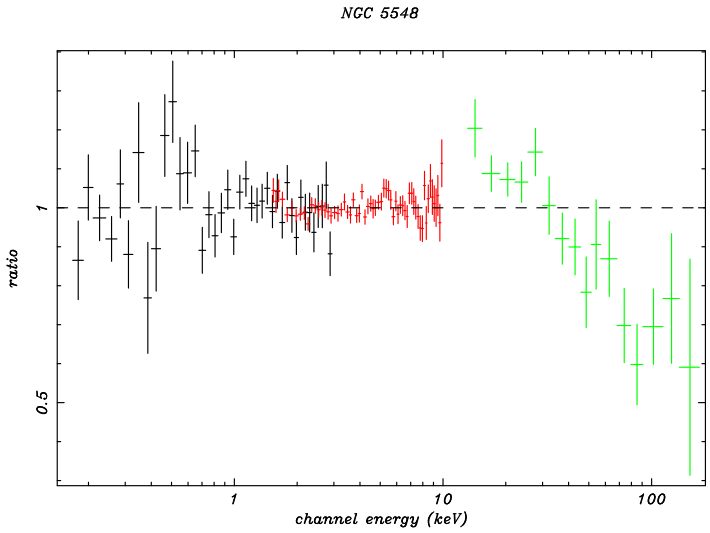

Figure 4: The complex broad band spectrum of NGC 5548 as seen by BeppoSAX. The residuals from the best model (before BeppoSAX) plotted in figure show the presence of an high energy cut-off and an emission line around 0.6 keV

keV, but above 10 keV the ratio should continue to decrease with energy (thin line), contrary to what observed. This is fixed with a constant reflection component, whose presence is already required by spectral fitting (Piro *et al.* 1998), (thick line). Note also as the intensity of the iron line remained constant, notwithstanding the substantial change of the ionizing flux (see also Perola *et al.* 1986). This suggests that the line region is far from the central source and possibly is the same site of the reflection component.

Intrinsic spectral variability narrows substantially the range of models of the intrinsic continuum. This point has not received much attention by theoreticians (with some noticeable exceptions), probably because the only solid evidence of intrinsic spectral variability was that of NGC 4151. With the broad-band spectral capability of BeppoSAX we can address this issue with much less ambiguities than in the past. Indeed, in the long-look observation of NGC 5548 we find a behaviour similar to that observed in NGC 4151 (fig. 3).

3 The high energy cut-off

With the exception of NGC 4151, where the high energy cut-off E_C is fairly well determined (Piro *et al.* 1998 and references therein), in other Seyfert galaxies only an average value has been derived (Zdziarski *et al.* 1995). With BeppoSAX we can measure E_C in single objects, with the perspective of studying its correlation with α and the luminosity (or the compactness parameter). The long observation of NGC 5548 has allowed to determine fairly precisely the cut-off ($E_C = 140^{+60}_{-30}$ keV, Nicastro *et al.* 1999), even with the source at a rather low flux (Fig.4). It should be also possible, at least in the brightest objects, to search for changes of E_C correlated with intensity. Indeed, in NGC 4151, there may be an indication of a variation of E_C from the low to the high state (upper panel of Fig.3).

4 REFERENCES

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